PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in and relating to welding electrodes and the like

We, HIRST ELECTRIC INDUSTRIES LIMITED, a British Company of Gatwick Road, Crawley, Sussex, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to electrodes. The word "electrode" in the following specification and claims means any electrically conductive member which is used to make or break an electric circuit by surface contact or absence of contact respectively with other electrically conductive material, and in particular it is intended to include both welding electrodes and contacts for switch gear, with both of which types of electrodes this invention is more particularly concerned.

Welding electrodes are normally disposed in a secondary transformer circuit in a resistance welding machine and by their design enable electrical current to be conveyed to the point or points on the component parts where a resistance weld is required. Such electrodes are generally of a circular cross-section fitting into the socket of an electrode holder and the most common electrode material in use is high conductivity copper or copper alloy.

Welding electrodes should possess good electrical and thermal conductivity with a high resistance to deformation at the temperatures employed, but copper and the copper alloys normally in use soften under the influence of heat developed at the tip during welding to produce appreciable deformation.

It is an object of the invention in one preferred form to reduce the heat deformation of welding electrodes. Similar deformation occurs in certain contacts of electrical switch gear, for example in relay contact tips, where sparking or arcing may give rise to heating of the contacting surfaces, and the invention is also applicable to this type of electrode.

In accordance with the invention there is provided an electrode (as defined herein) comprising a current carrying body portion of a copper or copper alloy of high electrical conductivity having a contacting surface of dispersion strengthened copper.

The contacting surface may be formed by a tip or facing, or an insert, as will become apparent, and may be joined to the body portion by brazing, or without the use of solder or similar additive material.

The preferred dispersion strengthened copper material comprises aluminium oxide as the disperse phase.

The invention also includes a method of fabricating an electrode as defined above comprising the steps of cold compacting a copper powder containing a suitable disperse phase to the form of a billet, sintering the billet in a controlled atmosphere, extruding the billet, cutting a portion from the extruded billet and uniting the portion so formed to the end of a said body portion to provide the contacting surface.

As one alternative, the method may comprise the steps of cold compacting a copper powder containing a suitable disperse phase to a portion of final desired shape, sintering the portion in a controlled atmosphere, and uniting the portion so formed to the end of a said body portion to provide the contacting surface.

As another alternative the method may comprise the steps of sintering a copper powder containing a suitable disperse phase by applying pressure to the powder in a controlled atmosphere in a mould part of electrically resistive material heated by the passage of an electric current to a suitable temperature below the melting point of cop-

per, the mould being shaped to form the powder into a portion of final desired shape, and uniting the portion so formed to the end of a said body portion to provide the contacting surface.

The portions may be united by brazing, or by a hot pressing technique without the use of a solder or similar additive material.

Preferred embodiments of the invention are hereafter more particularly described with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of part of a known resistance welding machine illustrating the function of the welding electrodes,

Figures 2, 3 and 4 are side elevational views of different types of welding electrode in accordance with the invention,

Figures 5, 6 and 7 are vertical sections through various electrodes for use as contacts for switch gear,

Figure 8 is a vertical section through a form of apparatus which may be used in making the electrodes of the invention (taken along the line VIII-VIII of Figure 9), and

Figure 9 is a section along the line IX-IX of Figure 8.

Figure 1 shows a portion of a known resistance welding machine in which upper and lower electrodes respectively 1 and 2 are inserted in rod-like holders respectively 3 and 4, which are respectively connected to electrical leads (not shown) and to coolant conduits 5 and 6 and are adjustably mounted by means of clamping bolts 7 in relatively movable arms 8 and 9 of the machine. In operation the plates (or other articles) to be welded are positioned between the electrodes and the arms are brought together to complete the contact with the plates, providing a circuit through the thickness of the plates.

Figures 2, 3, and 4 show different types of welding electrode which may be inserted in the positions indicated at 1 and 2 in Figure 1. Conventionally such electrodes would be integrally constructed of copper or copper-alloy to the external shape indicated. The body portion 11 of each electrode may be provided with means such as a recess 10 to enable it to be press fitted into the holders 3, 4 of the welding machine. The welding elements of the invention as illustrated in Figures 2, 3 and 4 retain a body portion 11 of copper or copper alloy of which the contacting surface, that is the surface which makes contact with the piece to be welded, is constituted of dispersion strengthened copper. As illustrated the contacting surface may be formed by portions of different shape.

The contacting surface of the welding electrode of Figure 2 is formed by a rod-like insert 12*a*, which protrudes from the body portion 11, which may be bevelled to prevent inadvertant contact between the metal to be welded and the body portion 11, and the base end of the insert 12*a* is recessed into the end of the body portion 11 to assist its anchorage.

The contacting surface of the welding electrode of Figure 3 is formed by a generally hemispherical tip or facing 12*b*, joined to the top of the body portion 11 and forming a complete extension of the body portion 11.

The contacting surface of the welding electrode of Figure 4 is formed by a cylindrical, plate-like tip or facing 12*c*.

The switch contacts shown in Figures 5, 6 and 7 are provided with tips or facings of various shapes 12*d*, 12*e*, 12*f* joined to body portions 11′ of for example copper or copper alloy to provide the contacting surfaces.

Dispersion strengthened copper is a known material and for a fuller discussion of the material and its properties reference may be made to an article "Improved strength for copper" published in "Copper" volume No. 29, Autumn 1966. The material is also discused in A.E.I. Research Publication No. H.R.L. 14 entitled "Dispersion of Strengthened Copped". This material consists of copper containing a uniform dispersion of very fine inert particles of a refractory disperse phase, which, for the purpose of this specification is selected from oxides, nitrides, and carbides. The particles are usually oxide particles because of their great thermodynamic stability. Techniques for making the material include the mechanical mixing of the metal with powders, the internal oxidations of dilute solid solution alloy powders, the decomposition of mixed metal salts and the incorporation of the metal's own oxide from the surfaces of powder particles. A preferred form of dispersion strengthened copper for use in the present invention consists of a product obtained by a powder metallurgy technique from a copper powder of very high purity containing a fine dispersion of aluminium oxide within each particles.

An example of the known technique for producing such a powder is as follows. Firstly a copper aluminium alloy is produced from high purity copper and a proportion of preferably between 1 and 4 volume % of aluminium. The alloy is ground to a powder and the powder is first heated in oxygen, producing a surface skin of oxide and is secondly heated in a neutral atmosphere, so that the oxide skin provides a source of oxygen which diffuses into the particles at a partial pressure sufficient to oxidise the aluminium. Residual copper oxide is removed from the powder by chemical reduction in hydrogen, resulting in

a copper powder of the desired purity containing the necessary fine dispersion of aluminium oxide within each particle.

The powder so produced may be formed into a solid element by compacting it in a cold state isostatically at for example 20 tons per square inch into, for example, cylindrical billets and sintering the billets in a controlled oven at ambient pressure and inert or reducing atmosphere such as hydrogen at 1000°C. The sintered billets may be extruded at for example approximately 700°C with an extrusion ratio of at least about 15:1. A portion intended to provide the contacting surface may then be cut and shaped from the extrusion product. It may consist for example of a shaped tip, or plate-like facing which may be directly brazed to the body portion of a welding element or electric contact. Silver solder may be used for this purpose or a silver-copper-phosphorous brazing alloy for which a flux is unnecessary.

Alternatively the powder may be cold pressed during the compacting step directly to the precise shape and dimensions which are required. The ready shaped portions are then sintered as described above.

As an alternative to brazing the contacting surfaces to the electrode bodies they may be directly united by hot pressing, for example through the use of a known "Electro-gas" technique or by adapted techniques of butt resistance welding. For an account of electro-gas technology, reference may be made to a pamphlet entitled "Electro-Gas, Soldering, Brazing, Hardening and Annealing", published by Standard Telephones and Cables Ltd. in April 1963. In this case the two parts to be joined are held together under pressure, for example, 10 lbs. per square inch and heated to a little below the melting point of copper, for example 1000°C. The electro-gas technique ensures a uniform localised temperature at the join by process timing.

In an adaptation of butt resistance welding, the desired temperature may be achieved by inserting between the faces to be joined a material of high resistance which is withdrawn when the temperature of 1000°C is attained, pressure being instantaneously applied following the normal procedure of this technique.

The apparatus illustrated in Figure 8 may be used in butt resistance welding ready-made tips, facings, or inserts to electrode bodies, or in making such portions themselves in a single step from the powder, or to make the electrodes of the invention in a one step procedure. The apparatus comprises a mould 20 which may, for example be 2½ inches in diameter and 3 inches in length and which may be made, for example of high resistance hard graphite. An axial bore of the same diameter as the electrode body is drilled part way through the mould and a cylindrical former 21 of the same material as the mould and of the same diameter as the bore is arranged to slide within the bore. The mould 20 is clamped between cup-sectioned copper connectors 22 which are connected in the secondary circuit of a transformer adapted to provide a current of, for example 5000 to 12000 amps., which is adapted to bring the temperature of the mould to a little below the melting point of copper, for example 1000°C.

The portions intended to provide the contacting surfaces may be made in the apparatus by part filling the bore in the mould 20 with the powder described, allowing for a suitable volume reduction of, for example 4:1. The mould is brought to 1000°C with the former in position and under a pressure of, for example, 500 to 2000 lbs. per square inch, supplied, for example, by the piston 23 of a pneumatic actuator. In this way the powder is sintered under pressure in one step to the desired shape. The mould should be flushed with an inert or reducing gas before the powder is heated. The carbon mould can afterwards be broken to extract the finished tip.

When the apparatus is to be used in making the electrodes in a single operation, the graphite former 21 is replaced by the electrode body, so that the contacting surface as it is formed, is united to the end of the body.

It will be apparent that ready made portions providing the contacting surfaces (made in other ways) may be inserted instead of powder into the bore in the mould for uniting to electrode bodies in a similar way. The mould 20 and former 21 may be made of materials alternative to graphite, for example stainless steel. In such a case the mould is suitably divided into two halves along a diameter, to allow removal of the sintered tips.

It is of advantage to form a recess in the adjoining face of the body portion as shown in the upper broken lines in Figure 2, to improve the anchorage and the electrical conductivity at the join, particularly when relatively narrow inserts as shown in Figure 2 are used to provide the contacting surface.

The preferred electrodes in accordance with the invention have high thermal stability, low creep ratio and a resistance to recovery and recrystallisation at temperatures approaching the melting point of the copper. As the copper matrix is also largely unaffected by the inert particles, the physical and chemical properties such as the electrical and thermal conductivity are only marginally affected.

A typical tip of dispersion strengthened

copper containing aluminium oxide as described has an electrical conductivity approaching 95% I.A.C.S. and a Vickers hardness of 110 at 950°C, for a 1 volume % of aluminium oxide. For a 4 volume % of aluminium oxide, an electrical conductivity of over 80% I.A.C.S. and a Vickers hardness of 160 at 950°C is obtained.

If desired, predetermined proportions of powders of hard metals such as nickel tungsten and molybdenum or related hard compounds with tungsten carbide may be mixed with the copper powder before sintering, following generally the same procedures described in fabricating the contacting surface. For example from 15% to 40% by weight of tungsten or molybdenum or tungsten carbide powder may be used. Graphite may also advantageously be added to the copper powder, generally in the range from 2% to 20% by weight and preferably approximately 5% by weight. The addition of graphite provides self-lubricating properties to the electrode which confers advantages when this is used for sliding contact. The addition of hard metals further increases the hardness of the dispersion strengthened copper at the expense of the conductivity, for example the inclusion of 40% of tungsten to standard copper increases the hardness to 200 Vickers hardness compared to standard copper in the annealed condition of 35, the decrease in conductivity being from 94% to 28%. The advantages of accruing are a better wearing surface and greater resistance to arcing and welding. Such materials are suitable both for electrodes and for specialised application in switch gear.

It will be appreciated that the embodiments shown are only illustrative and that features of one embodiment may be applied to other embodiments. The electrodes may be made in other ways. For example a laminated material composed of copper and copper allow and dispersion strengthened copper may be produced by the hot presssing procedure described. The laminate may be rolled into a composite sheet or extruded. The electrode may afterwards be fashioned from such materials.

WHAT WE CLAIM IS:—

1. An electrode (as defined herein) comprising a current carrying body portion of copper or copper alloy of high electrical conductivity having a contacting surface of dispersion strengthened copper.

2. An electrode as claimed in claim 1 wherein the said contacting surface is formed by a tip or facing extending over the cross-sectional area of the body portion.

3. An electrode as claimed in claim 1 or claim 2 wherein the said contacting surface is formed by an insert which protrudes from the said body portion.

4. An electrode as claimed in claim 2 or claim 3 wherein the tip, facing or insert is brazed to the metal of the body portion.

5. An electrode as claimed in claim 2 or claim 3 wherein the tip, facing or insert is united to the said body portion without the use of solder or similar additive material.

6. An electrode as claimed in any preceding claim wherein the tip ,facing or insert is partly recessed within the said body portion.

7. An electrode as claimed in any preceding claim wherein the dispersion strengthened copper comprises aluminium oxide as the disperse phase.

8. An electrode as claimed in any preceding claim constructed as a welding electrode.

9. An electrode as claimed in any preceding claim constructed as a contact for switch gear.

10. An electrode substantially as described herein with reference to the accompanying drawings.

11. An electrode as claimed in any preceding claim wherein the said dispersion strengthened copper has dispersed therein a proportion of hard metal or metal carbide.

12. An electrode as claimed in any of claims 1 to 10 wherein the said dispersion strengthened copper has dispersed therein a proportion of graphite.

13. An electrode as claimed in claim 11 wherein the said dispersion strengthened copper has dispersed therein from 15% to 40% by weight of tungsten or molybdenum or tungsten carbide.

14. An electrode as claimed in claim 12 wherein the graphite is present in amount from 2 to 20% by weight.

15. A method of fabricating an electrode as claimed in any preceding claim comprising the steps of cold compacting a copper powder containing a suitable disperse phase to the form of a billet, sintering the billet in a controlled atmosphere, extruding the billet, cutting a portion from the extruded billet and uniting the portion so formed to the end of a said body portion to provide the contacting surface.

16. A method of fabricating an electrode as claimed in any of claims 1 to 14 comprising the steps of cold compacting a copper powder containing a suitable disperse phase to a portion of final desired shape, sintering the portion in a controlled atmosphere, and uniting the portion so formed to the end of a said body portion to provide the contacting surface.

17. A method of fabricating an electrode as claimed in any of claims 1 to 14 comprising the steps of sintering a copper powder containing a suitable disperse phase by applying pressure to the powder in a controlled atmosphere in a mould part of electrically resistive material heated by the pass-

age of an electric current to a suitable temperature below the melting point of copper, the mould being shaped to form the powder into a portion of final desired shape, and uniting the portion so formed to the end of a said body portion to provide the contacting surface.

18. A method as claimed in claim 15 wherein the said contacting surface portion is brazed to the said body portion.

19. A method as claimed in any of claims 15 to 17 wherein the said contacting surface portion is united by a hot pressing technique to the said body portion without the use of solder or similar additive material.

20. A method as claimed in claim 19 wherein the said hot pressing technique is an electro-gas technique.

21. A method as claimed in claim 19 wherein the said body portion is pressed against the contacting surface portion in a mould part of electrically resistive material heated by passage of an electric current.

22. A method as claimed in claim 17 wherein the said pressure is applied by forcing a said body portion against the powder in the mould whereby the contacting surface portion is united to the said body portion as it is formed.

23. A method of fabricating an electrode as claimed in any of claims 1 to 14 substantially as described herein with reference to any of the modes of operation of the apparatus of Figures 8 and 9 of the accompanying drawings.

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1,177,351 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

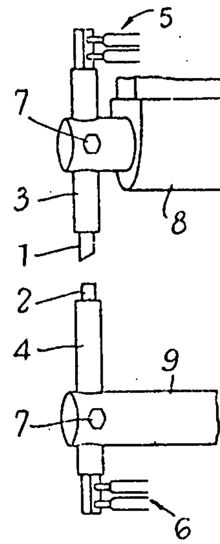


FIG.1

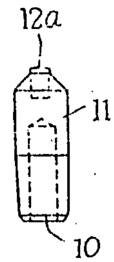


FIG. 2

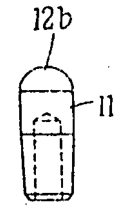


FIG. 3

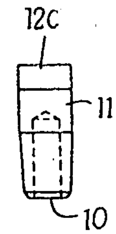


FIG.4

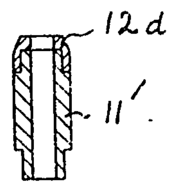


FIG. 5

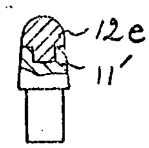


FIG.6

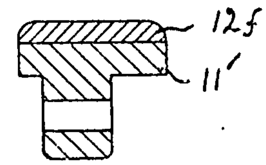
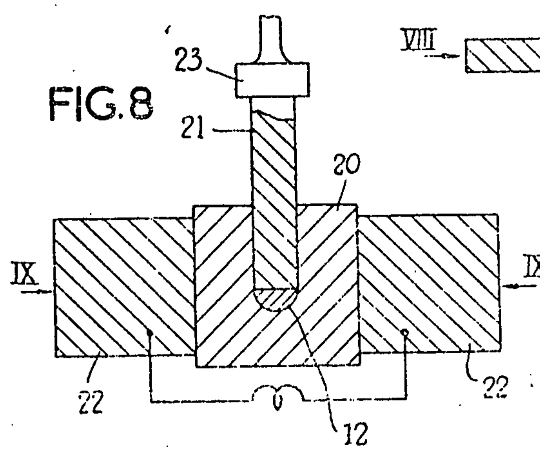


FIG.7

FIG.8



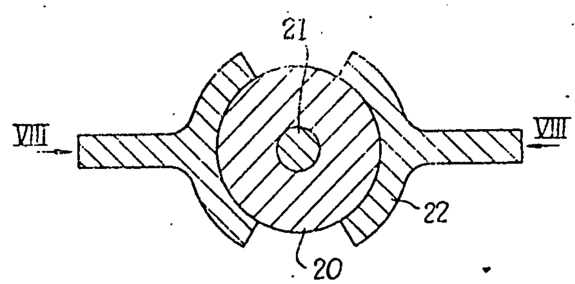


FIG.9